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Subjective measures of consciousness in artificial grammar learning task

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ABSTRACT

Consciousness can be measured in various ways, but different measures often yield different conclusions about the extent to which awareness relates to performance. Here, we compare five different subjective measures of awareness in the context of an artificial grammar learning task. Participants ($N = 217$) expressed their subjective awareness of rules using one of five different scales: confidence ratings (CRs), post-decision wagering (PDW), feeling of warmth (FOW), rule awareness (RAS), and continuous scale (SDS). All scales were equally sensitive to conscious knowledge. PDW, however, was affected by risk aversion, and both RAS and SDS applied different minimal criteria for rule awareness. CR seems to capture the largest range of consciousness, but failed to indicate unconscious knowledge with the guessing criterion. We close by discussing the theoretical implications of scale sensitivity and propose that CR's unique features enable (in conjunction with RAS and FOW) a finer assessment of subjective states of awareness.

1. Introduction

How "implicit" is implicit learning? How "implicit" is implicit perception? The extent to which implicit knowledge is conscious continues to be the central issue in the broad domain of implicit cognition (see e.g. Berry, 1995; Destrebecqz & Cleeremans, 2001; Pothos, 2007). In contrast to initial accounts (Reber, 1967, 1989; Seger, 1994), multiple studies now suggest that participants are at least partially aware of knowledge acquired through implicit learning procedures (Dienes & Seth, 2010; Higham, Vokey, & Pritchard, 2000; Perruchet & Pacteau, 1990; Shanks & St. John, 1994). It has also been suggested that subliminal priming could be driven, at least in part, by conscious perception (Holender, 1986; Kouider & Dupoux, 2004; Pessoa, Japee, & Ungerleider, 2005). However, the extent of the contribution of explicit knowledge or perception observed in those studies seems to depend on a measure of awareness that was used. The challenge of identifying the best measure of consciousness is thus critically important to any study of implicit cognition, and more generally, to investigate differences between conscious and unconscious processing. The main goal of this paper is to investigate the measures of awareness that are currently used, and to propose how they should be used to increase their sensitivity.

In the following section, we briefly describe objective and subjective measures of consciousness. Then, we present and compare different scales of subjective consciousness, discussing why different measures may yield different conclusions about the extent to which awareness relates to performance.

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1.1. Subjective and objective measures of consciousness

Estimating level of consciousness requires sensitive measures that make it possible to determine to what extent a person is aware of what was acquired or perceived. Multiple measures of consciousness have been proposed in that context. Most often, participants are just asked whether they are aware of being in a certain mental state and their unassisted verbal reports are then collected. Such introspective measures are broadly used in implicit cognition studies,[1] often revealing dissociations between awareness and performance, e.g. in the artificial grammar learning or subliminal priming studies. In the artificial grammar learning paradigm (Reber, 1989), participants are asked to memorize strings of letters which, unknown to them, are based on a set of rules that determine the sequence of successive letters. In a second phase of the task, participants are informed about the occurrence of the rules, and then asked to classify new strings as a function of whether or not they are "grammatical". Interestingly, participants usually report neither awareness of the learning process nor of the acquired knowledge. Nevertheless, their performance on indirect tests of knowledge indicates that learning occurred because their classification accuracy exceeds chance. Thus, dissociation between awareness and performance is observed. Similarly, in the case of subliminal priming, rapid and masked presentation of stimuli prior to targets influences participants' behavior (e.g. a facilitation of processing for congruent visible targets is observed), even though participants claim not to have seen the stimuli (Merikle, Smilek, & Eastwood, 2001). Do such results imply that participants are indeed unaware what was acquired or perceived? Not necessarily—it could be the case, for instance, that participants are partially aware, yet unable or unwilling to express their knowledge verbally, for instance, because of a reluctance to express knowledge held with low subjective certainty, or because the aspect of awareness they base their responses on is difficult to verbalize. Verbal reports have thus been often criticized as being inherently subjective and insensitive measures of consciousness, both in implicit learning (Kinder, Shanks, Cock, & Tunney, 2003; Shanks & St. John, 1994) and subliminal perception studies (Holender, 1986; Pessoa et al., 2005).

It is essentially for this reason that many authors prefer using objective measures to assess awareness. With such measures, participants are usually asked to perform some detection or discrimination task, in which consciousness is indicated by better-than-chance performance. This is in line with the theoretical assumption that awareness might be investigated by means of accessibility in a manner that is not necessarily related to a phenomenological experience (see A-consciousness vs. P-consciousness distinction, Block, 1995). For example, in artificial grammar learning studies, fragment-recognition or fragment-completion tasks are usually used as objective measures of awareness (Jamieson & Mewhort, 2009; Perruchet & Pacteau, 1990; Vokey & Brooks, 1992). Thus, in contrast with the dissociations typically found with subjective measures, objective methods often suggest that the knowledge acquired in artificial grammar learning or other paradigms investigating implicit learning is (at least partially) consciously accessible (Perruchet & Pacteau, 1990; Shanks & Channon, 2002; Shanks, Rowland, & Ranger, 2005; Shanks & St. John, 1994). Signal detection theory (Macmillan & Creelman, 1991) is usually applied to analyze the results of objective measures, and stimulus detection/discrimination sensitivity (d') is computed as an index of conscious access (Gaillard, Vandenberghe, Destrebecqz, & Cleeremans, 2006; Holender, 1986; Snodgrass, Bernat, & Shevrin, 2004).

The higher level of consciousness indicated by objective measures suggests that these measures are more sensitive. However, objective measures may be criticized for failing to capture the very central aspect of consciousness, namely subjective experience (or, in other words, measuring A-consciousness without P-consciousness). From this perspective, the fact that more knowledge is revealed through objective measures does not indicate greater sensitivity to the contents of awareness, but merely the effectiveness of information processing (Lau, 2008). Of course, it may be assumed that subjective experience is not essential to study conscious access at all (see e.g. worldly discrimination theories as described by Seth, Dienes, Cleeremans, Overgaard, & Pessoa, 2008), or that accessibility of knowledge and subjective experience related to this knowledge should be somehow separated (Block, 1995, 2011). However, it has recently been argued that subjective experience is the critical feature of consciousness that should be always taken into account (Dienes & Perner, 2004; Lau, 2008; O'Regan, Myin, & Noë, 2005). The importance of this assumption is obvious in the case of implicit learning studies, where accuracy of recognition is considered as an objective measure. It may be that the recognition is driven by a feeling of familiarity or other, possibly unconscious process (see Pothos, 2007). If that is so, participants may simultaneously exhibit some knowledge with an objective test and declare being subjectively unaware of that knowledge. Therefore, identifying a measure that is both sensitive and reflective of participants' subjective experience appears to be essential, especially if one assumes that consciousness should be investigated by means of accessibility associated with a direct subjective experience. This is in line with recent theoretical proposals that those two aspects of consciousness cannot be separated (see e.g. Cohen & Dennett, 2011; Kouider, de Gardelle, Sackur, & Dupoux, 2010). Following this reasoning, we assumed that any measure of consciousness should capture both aspects. Such requirement seems to be fulfilled by subjective scales of awareness (Dienes & Perner, 2004; Dienes & Seth, 2010; Persaud, McLeod, & Cowey, 2007; Ramsøy & Overgaard, 2004). In the following section, we provide an overview of such methods.

[1] And in other studies on consciousness, e.g. on neural correlates of consciousness (see: Rees et al., 2002).